S P E C I F I C A T I O N

TO ALL WHOM IT MAY CONCERN:

Be it known that we, William Vablais, a citizen of United

Kingdom, residing at 14917 Bear Creek Road NE, Woodinville,

Washington 98072, Lyndsay Williams, a citizen of the United

Kingdom, residing at 51 Weavers Field, Girton, Cambridge, CB3

0XB, United Kingdom, have invented a certain new and useful

ELECTRONIC MODULE FOR SENSING PEN MOTION of which the

following is a specification.

ELECTRONIC MODULE FOR SENSING PEN MOTION

FIELD OF THE INVENTION

The invention relates generally to digital ink, and more

5   particularly to writing instruments for generating digital ink

information.

BACKGROUND OF THE INVENTION

Digital ink technology enables a user to write and draw

10   on the touch-sensitive screen of a handheld PC or other

writing tablet with a stylus or other pointing device, and for

that information to be input into the computer, perhaps with

some enhancements such as handwriting recognition or display.

The technology provides a convenient means for applications to

15   accept input from a user without using a keyboard. For a

user, taking notes or drawing sketches using digital ink

technology is a convenient way to enter text or other

information into a computer without having to use a keyboard.

Most contemporary handwriting analyzers utilize a tablet

20   computer and a stylus. A user writes on the tablet computer

with the stylus, and coordinate, pressure, vector, and/or

other information generated by the contact of the stylus with

the tablet computer is utilized to recognize the writing

strokes of the user. A problem with this system is that

writing on a computer tablet does not feel the same as writing on paper. In addition, people prefer to write with more contemporary, ergonomic pens rather than with the thin stylus that is typically provided with a tablet computer.

5

SUMMARY OF THE INVENTION

The present invention provides an electronic module that inserts into or is otherwise associated with a pen or other writing instrument. The electronic module includes a

10 mechanism for detecting pen motion, such as an accelerometer, and is preferably mounted in a cavity that is designed for a substitute ink cartridge for a pen. An accelerometer may be used to measure the relative acceleration and deceleration of the pen in the X and Y axes, which in turn may be used to

15 provide a two-dimensional vector stream representing the pen's movement. Alternatively, the accelerometer may be arranged so that it senses tilt of the pen. In such a case, the information from the accelerometer may be used to plot relative X and Y components that represent the pen movements

20 that are generated by a user.

In addition to an accelerometer, a microcontroller, a battery, and a radio transmitter are mounted inside the module. Ballistic information generated by the accelerometer is transmitted via the radio transmitter to a computer (e.g.,

a personal computer), where processing and/or storage of the accelerometer information may occur. The accelerometer information may be used, for example, for handwriting recognition or digital ink generation.

5   The accelerometer and related components are preferably mounted within a cartridge that can be substituted for a conventional ink cartridge for a pen. Contemporary pens usually include two cartridges within the pen, a first cartridge that supplies ink to the nib, and a second cartridge

10   that presses the first cartridge against the nib. The components may be mounted in a cartridge that is placed in the position of the second cartridge. By mounting the components in this location, the pen functions normally as a writing instrument, and the user's writing experience is not altered.

15   The components may alternatively be placed within the first cartridge (i.e., the cartridge that supplies ink to the nib), wherein either the pen does not write, or the components within the first cartridge are shielded from, or impervious to, the ink.

20   The components in the electronic module are relative inexpensive. If the pen is lost, there is no security problem as there is no user data kept within the pen. If mounted inside a pen, the module does not interfere with the user's handwriting motions or the aesthetic appearance of the pen.

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If handwriting recognition software is used, the user is
provided with a hard copy of notes at the same time that a
digital copy is being generated. In addition, power on/off
may be accomplished by movement detection, so no on/off switch
5   would violate the outer shape of the user's pen.

Other advantages will become apparent from the following
detailed description when taken in conjunction with the
drawings, in which:

10   **BRIEF DESCRIPTION OF THE DRAWINGS**

FIGURE 1 is a block diagram representing a computer
system into which the present invention may be incorporated;

FIG. 2 is a block diagram representing an architecture
for a system that incorporates an electronic module that
15   generates writing movement information in accordance with one
aspect of the invention;

FIG. 3 is a representation of a graph of acceleration
versus time generated by the electronic module of the present
invention for an exemplary amount of handwritten data over
20   time;

FIG. 4 is a block diagram representing an architecture of
a more specific system utilizing an electronic module for
generating digital ink information in accordance with an
aspect of the invention;

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FIG. 5 shows a pen into which an electronic module in accordance with the present invention may be incorporated;

FIG. 6 shows an electronic module for the pen of FIG. 5; and

5   FIG. 7 shows a general overview of a process for generating digital ink information from writing input of a user using the electronic module in accordance with one aspect of the present invention.

DETAILED DESCRIPTION

Exemplary Operating Environment

Figure 1 illustrates an example of a suitable computing system environment 100 on which the invention may be

15   implemented. The computing system environment 100 is only one example of a suitable computing environment and is not intended to suggest any limitation as to the scope of use or functionality of the invention. Neither should the computing environment 100 be interpreted as having any dependency or

20   requirement relating to any one or combination of components illustrated in the exemplary operating environment 100.

The invention is operational with numerous other general purpose or special purpose computing system environments or configurations. Examples of well known computing systems,

environments, and/or configurations that may be suitable for

use with the invention include, but are not limited to,

personal computers, server computers, hand-held or laptop

devices, multiprocessor systems, microcontroller-based

5   systems, set top boxes, programmable consumer electronics,

network PCs, minicomputers, mainframe computers, distributed

computing environments that include any of the above systems

or devices, and the like.

The invention may be described in the general context of

10   computer-executable instructions, such as program modules,

being executed by a computer. Generally, program modules

include routines, programs, objects, components, data

structures, and so forth, which perform particular tasks or

implement particular abstract data types. The invention may

15   also be practiced in distributed computing environments where

tasks are performed by remote processing devices that are

linked through a communications network. In a distributed

computing environment, program modules may be located in both

local and remote computer storage media including memory

20   storage devices.

With reference to Figure 1, an exemplary system for

implementing the invention includes a general-purpose

computing device in the form of a computer 110. Components of

the computer 110 may include, but are not limited to, a

processing unit 120, a system memory 130, and a system bus 121
that couples various system components including the system
memory to the processing unit 120. The system bus 121 may be
any of several types of bus structures including a memory bus

5   or memory controller, a peripheral bus, and a local bus using
any of a variety of bus architectures. By way of example, and
not limitation, such architectures include Industry Standard
Architecture (ISA) bus, Micro Channel Architecture (MCA) bus,
Enhanced ISA (EISA) bus, Video Electronics Standards

10 Association (VESA) local bus, and Peripheral Component
Interconnect (PCI) bus also known as Mezzanine bus.

Computer 110 typically includes a variety of computer-
readable media. Computer-readable media can be any available
media that can be accessed by the computer 110 and includes

15 both volatile and nonvolatile media, and removable and non-
removable media. By way of example, and not limitation,
computer-readable media may comprise computer storage media
and communication media. Computer storage media includes both
volatile and nonvolatile, removable and non-removable media

20 implemented in any method or technology for storage of
information such as computer-readable instructions, data
structures, program modules, or other data. Computer storage
media includes, but is not limited to, RAM, ROM, EEPROM, flash
memory or other memory technology, CD-ROM, digital versatile

disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can accessed by the computer

5   110. Communication media typically embodies computer-readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media. The term "modulated data signal" means a signal that

10   has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared

15   and other wireless media. Combinations of the any of the above should also be included within the scope of computer-readable media.

The system memory 130 includes computer storage media in the form of volatile and/or nonvolatile memory such as read

20   only memory (ROM) 131 and random access memory (RAM) 132. A basic input/output system 133 (BIOS), containing the basic routines that help to transfer information between elements within computer 110, such as during start-up, is typically stored in ROM 131. RAM 132 typically contains data and/or

program modules that are immediately accessible to and/or presently being operated on by processing unit 120. By way of example, and not limitation, Figure 1 illustrates operating system 134, application programs 135, other program modules

5   136, and program data 137.

The computer 110 may also include other removable/non-removable, volatile/nonvolatile computer storage media. By way of example only, Figure 1 illustrates a hard disk drive 140 that reads from or writes to non-removable, nonvolatile

10 magnetic media, a magnetic disk drive 151 that reads from or writes to a removable, nonvolatile magnetic disk 152, and an optical disk drive 155 that reads from or writes to a removable, nonvolatile optical disk 156 such as a CD ROM or other optical media. Other removable/non-removable,

15 volatile/nonvolatile computer storage media that can be used in the exemplary operating environment include, but are not limited to, magnetic tape cassettes, flash memory cards, digital versatile disks, digital video tape, solid state RAM, solid state ROM, and the like. The hard disk drive 141 is

20 typically connected to the system bus 121 through a non-removable memory interface such as interface 140, and magnetic disk drive 151 and optical disk drive 155 are typically connected to the system bus 121 by a removable memory interface, such as interface 150.

The drives and their associated computer storage media, discussed above and illustrated in Figure 1, provide storage of computer-readable instructions, data structures, program modules, and other data for the computer 110. In Figure 1,

5   for example, hard disk drive 141 is illustrated as storing operating system 144, application programs 145, other program modules 146, and program data 147. Note that these components can either be the same as or different from operating system 134, application programs 135, other program modules 136, and

10 program data 137. Operating system 144, application programs 145, other program modules 146, and program data 147 are given different numbers herein to illustrate that, at a minimum, they are different copies. A user may enter commands and information into the computer 20 through input devices such as

15 a keyboard 162 and pointing device 161, commonly referred to as a mouse, trackball or touch pad. Other input devices (not shown) may include a microphone, joystick, game pad, satellite dish, scanner, a touch-sensitive screen of an handheld PC or other writing tablet, or the like. These and other input

20 devices are often connected to the processing unit 120 through a user input interface 160 that is coupled to the system bus, but may be connected by other interface and bus structures, such as a parallel port, game port or a universal serial bus (USB). A monitor 191 or other type of display device is also

connected to the system bus 121 via an interface, such as a

video interface 190. In addition to the monitor, computers

may also include other peripheral output devices such as

speakers 197 and printer 196, which may be connected through

5   an output peripheral interface 190.

The computer 110 may operate in a networked environment

using logical connections to one or more remote computers,

such as a remote computer 180. The remote computer 180 may be

a personal computer, a server, a router, a network PC, a peer

10   device or other common network node, and typically includes

many or all of the elements described above relative to the

computer 110, although only a memory storage device 181 has

been illustrated in Figure 1. The logical connections

depicted in Figure 1 include a local area network (LAN) 171

15   and a wide area network (WAN) 173, but may also include other

networks. Such networking environments are commonplace in

offices, enterprise-wide computer networks, intranets and the

Internet.

When used in a LAN networking environment, the computer

20   110 is connected to the LAN 171 through a network interface or

adapter 170. When used in a WAN networking environment, the

computer 110 typically includes a modem 172 or other means for

establishing communications over the WAN 173, such as the

Internet. The modem 172, which may be internal or external,

may be connected to the system bus 121 via the user input
interface 160 or other appropriate mechanism. In a networked
environment, program modules depicted relative to the computer
110, or portions thereof, may be stored in the remote memory

5 storage device. By way of example, and not limitation, Figure
1 illustrates remote application programs 185 as residing on
memory device 181. It will be appreciated that the network
connections shown are exemplary and other means of
establishing a communications link between the computers may

10 be used.

Electronic Module For Sensing Pen Motion

Typically, a user writing on a touch-sensitive screen or
tablet generates digital ink information with a stylus or

15 other writing instrument. Generally, digital ink technology
stores and/or processes information about stylus, mouse, or
other pointer movements, along with enhanced information such
as calculated vector information, pressure, timing, strokes,
angle of stylus, italic and bold states, and the like. There

20 are a variety of different digital ink formats, and the
additional information that the format can store or process
with the pointer movements varies for the different
applications.

In summary, the present invention is directed to an electronic module that may be inserted inside a pen, or otherwise may be attached to a pen or other writing instrument. The electronic module includes components that

5 generate data as a result of pen movements. The data may be used to create digital ink information. In accordance with one aspect of the present invention, the electronic module includes a ballistic information generator (e.g., an accelerometer) that generates ballistic pen movement and/or

10 ballistic pen tilt information in response to movements of the pen. The ballistic information may then be used for handwriting recognition, digital ink generation, or the like.

Turning now to the drawings, FIG. 2 shows generally an architecture for a system 200 in which the present invention

15 may be incorporated. The system 200 includes a computer 202 (e.g., the computer 110) having a digital ink receiver 204. In use, the digital ink receiver 204 is configured to receive raw data generated by a user's writing movements (described below), process that data if necessary, and forward

20 corresponding appropriate data to a device driver 206. The device driver 206, in turn, is configured to notify interested client applications (e.g., operating system components or client applications 209_1, 209_2) of the data arrival, and forward that data to the client applications. The client

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applications may use the data as appropriate. As one example, a client application 209 may be a handwriting recognition software program that uses the data forwarded by the device driver in handwriting analysis or recognition. As another

5   example, a client application 209 may be a display device that displays the data generated by the system 200.

A filter 208 may be included in, or otherwise may be associated with, the device driver 206. The function of the filter 208 is described below.

10   The computer 202 is connected via a connection 210 to a ballistic generator module 222 that is mounted in, or otherwise associated with, a writing instrument 220, such as a pen, stylus, pencil, paintbrush, stick, a pointer device, or any other mechanism through which a user may perform writing

15   movements. As further described below, information about the writing instrument's movements is generated by the ballistic generator module 222 and is transmitted to the computer via the connection 210.

The connection 210 may be hardwired or wireless (wherein

20   if wireless, the connection is conceptual, e.g., line-of-sight for infrared, or within range for FM transmissions, and so forth). As some examples, the computer 202 may be located remotely from the writing instrument 220, and transmission of information regarding movements of the writing instrument 220

to the computer may occur via a wireless transmission, a local

area network (e.g., the LAN 171), a wide area network (e.g.,

the WAN 173), the Internet, or through another network or

similar connection. Alternatively, writing information may be

5   stored in memory in the writing instrument, and may be later

downloaded to the computer 202, wherein the connection 210 may

be a temporary hardwired or wireless connection, or a memory

module from the ballistic generator module 222 (or the entire

ballistic generator module for that matter) may be remove from

10   the writing instrument and the data therein may be downloaded

to the computer 202. In addition, some or all of the

functions of the digital ink receiver 204 and/or the device

driver 206 may be provided in the writing instrument and/or

the ballistic generator module 222, although in practice, such

15   a design may result in a mechanism that may be too cumbersome

for comfortable writing.

The ballistic generator module 222 includes components

that are configured to generate motion information, such as

acceleration and/or tilt information, as a result of writing

20   movements. The ballistic generator module 222 may include,

for example, a dual-axis accelerometer, or a pair of

accelerometers, or any other mechanism that is capable of

generating data regarding information about movement or tilt

of the writing instrument 220. Specific examples of

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components that may be used in the ballistic generator

module 222 are described below.

The writing instrument 220 also preferably includes an

appropriate tip 224 for writing on a surface 230 (e.g., paper,

5   a touch-sensitive screen, or a writing tablet). The tip 224

preferably is designed for optimum writing on the surface 230,

such as a blunt end for a touch-sensitive screen or tablet, or

a pen point or nib for writing on paper.

In practice, a user grips the writing instrument 220 and

10   writes with the tip 224 in a standard fashion, either on a

writing tablet, or on an ordinary writing surface (e.g.,

paper). The ballistic generator 222 generates ballistic

information regarding the writing instrument's movements

and/or tilts, such as may be caused by a user's writing. If a

15   touch-sensitive screen is utilized, additional digital ink

information, such as calculated vector information, pressure,

timing, strokes, angle of stylus, and the like, may be

generated by the touch-sensitive screen or tablet. Some of

this information may be sensed by one or more other sensors in

20   the pen, and similarly transmitted to the computer 202.

The ballistic information is transferred to the

computer 202 via the connection 210 and is received by the

digital ink receiver 204. The digital ink receiver processes

the data and forwards it to the device driver 206. As an

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example of what may be done to process the data, the digital
ink receiver 204 may convert raw tilt data from an
accelerometer to pitch and roll angles, as further described
below.

5   The filter 208 may smooth or otherwise alter the data
before the data is sent to the device driver 206 so that the
data may be more usable. For example, the raw angle data (X
and Y angle data) from the ballistic generator module 222 may
be noisy, and the filter 208 may be used to smooth the output
10 of each of the two channels of data independently, e.g., by
using known smoothing programs or the like. As one example of
a filtering solution, the following equation may be applied to
a sequence of raw data to filter a channel of data:

$$y[n] = \sum_{m=-K}^{+K} x[n-m].f[m]$$

15   In the above equation, the output of the filter is
denoted by $y[n]$, and a channel sequence of raw data is denoted
by $x[n]$, with n being the sequence (time) index. The array
$f[m]$ gives the coefficients of the filter, and K is chosen to
cover the range of non-zero $f[m]$ values (i.e. $f[\pm(K+1)]=0$).
20 Values may be arbitrarily chosen for $f[m]$, but the following
Gaussian profile works effectively:

$$f[m] = Z^{-1} \exp\left(\frac{-m^2}{\sigma^2}\right)$$

The factor Z is set such that the coefficients of the

filter sum to unity (i.e., it is a weighted averaging filter).

A filter width 'σ' may be chosen that gives a chosen, optimal

5   performance. The larger the filter width σ, the smoother the

filter. The appropriate value for σ should be determined

subjectively and typically will depend on the sampling rate.

The filtered data is sent to the device driver 206, which

in turn notifies interested client applications 209, e.g., via

10   a notification message. The notification message sent to

clients contains the filtered pitch and roll angles.

The client applications 209 may configure the properties

of the device driver 206 according to how the client

applications wish to utilize the incoming data stream. As one

15   example, a display application may configure the data so that

a display of the data is a specific correlation of the

movements of the writing instrument 220. If such an

application is used, the device driver 206 may be configured

to include a calibration function 240 (i.e., calibration

20   software) that is used to skew or stretch all input letters,

symbols, or other writing input that have been entered by the

user into a desired orientation relative to a point of

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reference. The calibration function 240 may thereby

compensate for a user's handwriting style (e.g., angle of

pen), as well as the orientation of the pen relative to

mounting of the motion or tilt sensing components of the

5   ballistic generator module 222. For example, the calibration

function 240 may compensate for drawings that are interpreted

on a display in a tilted position because of the orientation

of the motion/tilt sensor.

By way of example, the calibration function 240 may be

10   written so that all characters input by the writing instrument

are displayed in an upright fashion (i.e., as would be

normally seen without rotation). One way to perform such a

function is to direct a user, upon the beginning of each use

of the writing instrument 220, to draw a shape, such as a

15   square. The shape that is generated by the data from

ballistic generator module 222 may then be compared against

the orientation and relative dimensions of a calibration

square that is maintained elsewhere (e.g., in memory). The

calibration square may, for example, be displayed on a

20   computer screen relative to the data points generated by the

ballistic generator module. Using this information, the

software may create a calibration function 240 in the device

driver 206 that may be used to skew or stretch all symbols

that are input by the writing instrument 222. In this manner,

characters are consistently altered to a predetermined

relationship, such as in an upright, readable form.

As an example, FIG. 3 shows a representation of a square

300 that may be drawn by a user with the writing

instrument 220. The computer 202 generates a graph 310 that

represents a plot of the X and Y positions of the data

generated by the ballistic generator module 222. In the

embodiment shown, the data points for the square are plotted

as a parallelogram, with two sides being much longer than the

other two, and the parallelogram rotated about 45 degrees from

the original, written position. The rotation of the

parallelogram is a result of the orientation of the pen in the

user's hand. Thus, although the sides do not align vertically

and horizontally in the graph plot shown in FIG. 3, rotating

the writing instrument 220 in the user's hand may generate

another set of data points that align with the vertical and

horizontal axes in the graph. In any event, alignment of the

data plots may not be critical for some applications, because

the data points may be properly interpreted because they are

read relative to one another, and not to the orientation of

the graph 310. However, in some applications, such as a

program that attempts to accurately display a user's

handwriting movements on a display, the orientation is more

important. For such a program, a calibration function may be

utilized that effectively rotates the figure in accordance

with the arrow 320 shown in FIG. 3, and stretches the figure

in accordance with the arrows 330 (e.g., so that the shorter

sides of the parallelogram can equal the longer sides). In

5   this manner, a pen can be held in any position in the hand,

and a drawing may be accurately reflected on the screen.

FIG. 4 shows a representation of an embodiment of a

digital ink generation system 400 that incorporates the

present invention and that utilizes a wireless connection 410.

10   The wireless connection 410 includes a receiver 412 at the

computer 202, and a transmitter 414 in the electronic module

416 that is mounted in the writing instrument 420. The

writing instrument 420 in the example shown in FIG. 4 is a

pen 420.

15   The ballistic generator in the embodiment of FIG. 4 is an

accelerometer 422. The accelerometer 422 is preferably a

digital output accelerometer, such as the +/- 2g Dual-Axis

Accelerometer with Duty Cycle Output produced by Analog

Devices, Inc. of Norwood Massachusetts, under the model number

20   ADXL202E. If a digital output accelerometer is not used, an

analog-to-digital converter 426 may be utilized to generate

digital information. A microcontroller 428 is connected to

the accelerometer and the microcontroller 428 is wired to the

transmitter 414. A battery 440 is attached to the

microcontroller 420 to provide power to the circuit. If

desired, software (not shown) may be provided in conjunction

with the accelerometer that permits movement detection of the

writing instrument 420. In this manner, the accelerometer may

5 be used to turn on and off the electronic module 416.

The accelerometer 422 is arranged to produce tilt data

(i.e., the accelerometer is arranged to be used as a tilt

sensor). When used as a tilt sensor, an accelerometer uses

the force of gravity as an input vector to determine the

10 orientation of an object. An accelerometer is most sensitive

to tilt when its sensitive axis is perpendicular to the force

of gravity, i.e., parallel to the earth's surface. At this

orientation its sensitivity to changes in tilt is highest.

Thus, for the dual-axis accelerometer to be used as a tilt

15 sensor, it is preferred that the X and Y axes for the

accelerometer be aligned perpendicular to the axis of the

writing instrument 220, and parallel with the ground when the

pen is in an upright position.

For the tilt sensor embodiment, mounting the tilt sensor

20 422 adjacent to the top end of the writing instrument 420 may

produce the most accurate information, but the tilt sensor may

be mounted in other locations as desired. The location of the

tilt sensor 422 is dependent upon the location of the

electronic module 416, which may be varied according to the

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particular application. For example, the electronic module

416 of the embodiment shown in FIG. 4 is mounted inside a pen

420, but the module may also be mounted on the outside of a

writing instrument, for example when used with a paint brush

5   or wooden pencil. In such an embodiment, the electronic

module 416 may be attached by an elastic collar, glue, tape,

rubber bands, or in any other suitable manner.

The dual-axis digital accelerometer (e.g., the ADXL202e

accelerometer) generates ballistic angle movement information

10   in response to movements of the writing instrument 220. Pen

position data may be generated, for example, at 60

samples/sec/channel. The x and y channel data is read into

the microcontroller 428 and is combined into a single channel

of ASCII data for transmission by the transmitter 314, e.g.,

15   at 1200 Baud. The transmitter 314 may be, for example, a

433MHz, AM transmitter having a range up to 30 meters. The

transmission may or may not be encrypted.

The raw data from the accelerometer is received by the

digital ink receiver 404, and is converted to pitch and roll

20   angles in a manner known in the art (see, for example, the

product literature for the ADXL202E, incorporated herein by

reference). The pitch and roll angles may be filtered (e.g.,

by the filter 208) and/or compensated for (e.g., by the

calibration component 240), and may be used by client

applications, for example, to plot relative X and Y

components, which represent the pen movements that are

generated by a user.

The accelerometer 422 may be used to detect acceleration

5   and deceleration, instead of tilt information. In such an

embodiment, the relative acceleration and deceleration of the

pen in the X and Y axes that is measured by the

accelerometer 422 may be used to provide dynamic information

regarding the motion of the pen and hence form a two-

10   dimensional vector stream representing the pen movement.

Other pen movement information may be extracted from, for

example, a handwriting tablet, or sensors placed in the

writing instrument 220. The additional pen movement

information may also be used to extract vector information for

15   handwriting recognition.

FIG. 5 shows a contemporary fountain pen 500 in which an

electronic module 502 made in accordance with the present

invention may be inserted. Contemporary pens usually include

two identical ink cartridges within the pen, a first ink

20   cartridge 504 that supplies ink to the nib, and a second,

spare cartridge that presses the first cartridge against the

nib. In practice, the cartridges are switched when the first

cartridge is empty, thus permitting a spare supply of ink to

be carried with the pen. In accordance with one aspect of the

present invention, the components of the electronic module 502
(e.g., the components described with reference to the module
416, as shown in the cartridge 502 in FIG. 6) may be mounted
in a cartridge that is sized similar to one of the ink

5   cartridges, and is placed in the position of the second
cartridge. By mounting the components in this location, the
pen functions normally as a writing instrument, and the user's
writing experience is not altered. The components may
alternatively be placed within an electronic module in the

10   position of the first cartridge (i.e., the cartridge that
supplies ink to the nib), although this arrangement requires
either that the pen not be able to write, or that the
components be shielded from, or impervious to, the ink.

The components in the electronic module 502 are relative

15   inexpensive. If the pen 500 or the electronic module is lost,
there is no security problem as user data kept is normally not
kept within the pen. Because the electronic module 502 is
mounted inside the pen 500, the module does not interfere with
the user's handwriting motions or the aesthetic appearance of

20   the pen. In addition, power on/off may be accomplished by
movement detection, so no on/off switch would violate the
outer shape of the user's pen.

The electronic module 502 provides additional benefits in
that it may be used in a conventional pen, the use of which is

known by virtually everyone. A user may simply begin writing,

and the ballistic generator sends data regarding the user's

writing movements to the computer 202. If the computer is a

hand held device, for example, the user has a convenient,

5   easy-to-use, and portable data input system.

An electronic module in accordance with the present

invention may be implemented in a number of other ways. For

example, in addition to the above-described embodiments, an

electronic module may be incorporated as part of an ink

10   cartridge that extends the length of a pen. Alternatively, an

electronic module may be configured to fit into the end of a

mechanical pencil, such as in an eraser slot. Other

embodiments are contemplated.

Turning now to an explanation of the operation of the

15   present invention, FIG. 7 shows a general overview of a

process for generating handwriting data in accordance with one

aspect of the present invention. Beginning at step 700, a

user utilizes a writing instrument (e.g., the pen 320) to

generate ballistic information. As discussed above, the

20   ballistic information may be generated by an accelerometer or

by a tilt sensor (e.g., an accelerometer arranged to collect

tilt information) as a result of writing movements by a

writing instrument incorporating the electronic module.

At step 702, the ballistic information is received by the computer 202 (e.g., through the connection 210). The data is then filtered by the filter 208 (step 704). As discussed above, this filtering process may utilize, for example, a

5 Gaussian filtering technique. At step 706, the filtered data may then be altered as necessary (e.g., by the calibration function 240) for the software for which the data will be used. For example, the data may be stretch, rotated, and/or skewed so that it may be properly displayed on a monitor. The

10 altered data is then forwarded to the appropriate application (step 708). The application may be, for example, recognition or display software.

While the invention is susceptible to various modifications and alternative constructions, a certain

15 illustrated embodiment thereof is shown in the drawings and has been described above in detail. It should be understood, however, that there is no intention to limit the invention to the specific form or forms disclosed, but on the contrary, the intention is to cover all modifications, alternative

20 constructions, and equivalents falling within the spirit and scope of the invention.